Dynamics of Localized Currents and Eddy Variability in the Adriatic (DOLCEVITA)

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LONG-TERM GOALS

To contribute to the understanding of the dynamics of marginal seas such as the Adriatic by collecting and interpreting accurate Lagrangian observations of currents and satellite measurements of water mass properties (e.g., temperature, salinity, chlorophyll concentration). In particular, to study the variability of the surface velocity and temperature/chlorophyll fields in selected basins of the Mediterranean at the meso-, seasonal and interannual scales and to assess the impact of the wind forcing and fresh water runoffs.

OBJECTIVES

The main objective of the DOLCEVITA project is to quantify the kinematic and dynamic properties of the northern and middle Adriatic (NMA) Sea. In particular the experimental work includes the following tasks based on data provided by drifters and ancillary remote sensing observations (satellites and high-frequency coastal radars):

- Describe the NMA surface circulation variability (Eulerian and Lagrangian statistics, major scales of variability, particle dispersion, etc.) and separate this variability into mean (over 6 months), synoptic (~10 days), mesoscale (a few days) and high-frequency (tidal, seiches, inertial) components;

- Describe the spatial structure and temporal variability of predominant mesoscale features, such as the cold filaments rooted of the Croatian coast (NAF and MAF), and the instability of the Po River Plume and WAC;

- Relate the mesoscale flow characteristics to the thermal and pigment signatures;

- Study the effect of wind forcing (Bora and Sirocco conditions) and bathymetry on the above-mentioned mesoscale circulation features;

- Determine the contribution of mesoscale circulation to the spreading and flushing of buoyant waters of riverine origin, and to lateral heat transport;

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- Set up a new methodology using drifters, HF radars and remote sensing to study the mesoscale variability in coastal environments and marginal seas.

APPROACH

1) Assess the efficiency and usefulness of surface drifters equipped with GPS receivers.

2) Use a "random flight" model (Gaussian-Markov process) to seek an optimized drifter deployment strategy to map the mean flow and eddy variability and to quantify particle dispersion (Lagrangian statistics) in the NMA.

3) Deploy more than 100 drifters to monitor the surface circulation in most areas of the NMA for about a year (September 2002 to September 2003).

4) Estimate surface circulation statistics, both Eulerian and Lagrangian, for the entire NMA area. For example, produce mean circulation and eddy variability maps for each season and with spatial resolution of 10-20 km. Estimate Lagrangian statistics such as the integral time and length scales and eddy diffusivities.

5) Describe the spatial structure and temporal variability of the filaments, NAF and MAF. Eulerian maps of mean velocity and variance will be created on a monthly basis and with 5-10 km spatial resolution. Estimate one and two-particle dispersion statistics from the data given by the drifters deployed in clusters.

6) Compare qualitatively and quantitatively (regressions) the drifter data with the SST/pigment structures obtained from satellite data and with the surface velocity maps provided by high-frequency coastal radars.

7) Use the combined drifter and radar data to study the temporal variability and spatial structure of the surface circulation and in particular to assess the influence of wind forcing and river runoffs.

WORK COMPLETED

1) A total of 125 drifters were deployed in the NMA between September 2002 and September 2003. These include regular and GPS CODE drifters (64 and 45 units, respectively), five GPS SVP drifters with holey-sock drogue centered at 30/50 m depth, two GPS CODE drifters with 30/50-m long thermistor chains, two SVP/OCM drifters with up and downward-looking radiometers and seven CMOD (XAN-3) drifters with 30/50-m long thermistor chains.

2) Most drifters (75%) were released during hydrographic cruises of NRV Alliance (ADRIA02 – 16-Sep-02/13-Oct-02 and ADRIA03 – 26-Apr-03/12-May-03) and of R/V Knorr (DV1 – 31-Jan-03/24-Feb-03 and DV2 – 26-May-03/15-Jun-03). The drifter measurements during the DV1 and DV2 cruises were concentrated on selected mesoscale circulation features and were made in concert with towed vehicle, hydrographic, optical and turbulence measurements.

3) Some drifters were recovered intentionally during the hydrographic cruises. Others were recovered by seafarers or went ashore. Most of these recovered drifters were re-deployed in the NMA.

4) Graphical summaries (drifter tracks) were produced automatically on a daily-basis on a dedicated web site (http://doga.ogs.trieste.it/sire/dolcevita/).

5) The drifter data were archived, converted, and edited (de-spiked).

RESULTS

1) Basic drifter statistics: The drifter dataset between 21 September 2002 and 31 August 2003 includes 166 trajectories and represents a total of about 24 drifter-years. Due to the almost continuous re-seeding of drifters at strategic positions, the drifter population never decreased below 8 (minimum on 21-Sep-02). The maximum drifter density of 51 drifter-day per day was observed on 6-Jun-03. The maximum drifter lifetime was 278 days whereas the mean drifter half life was 38 days.

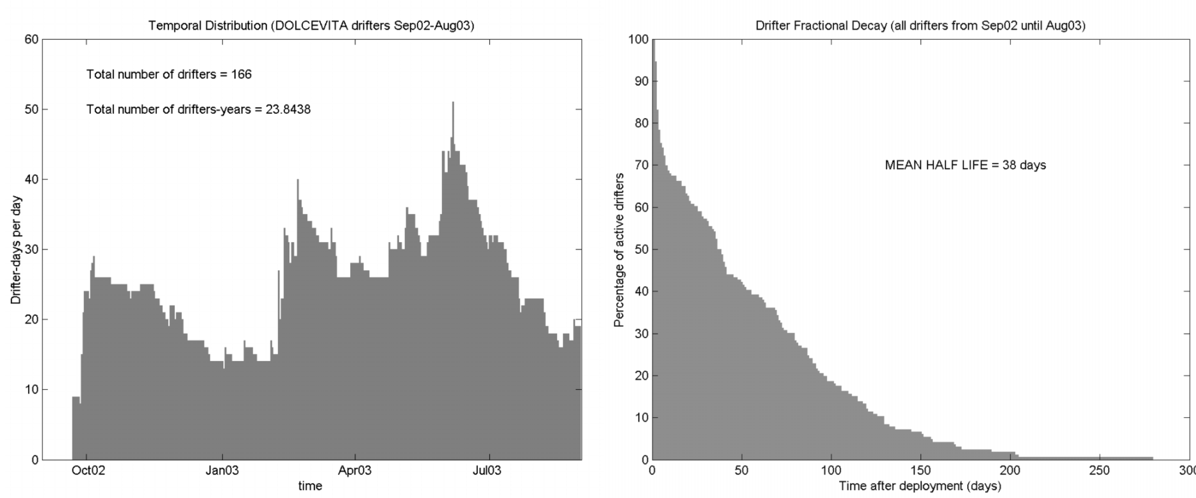

Fig. 1. (left) Temporal data distribution for the drifters deployed in the NMA between 21 September 2002 and 31 August 2003; (right) Drifter fractional life decay showing a maximum lifetime and a mean half life of 278 and 38 days, respectively.

2) Deployments and spatial coverage: The drifters were deployed in organized clusters (mostly triplets with distance between drifters not exceeding 1 nm) throughout the NMA in order to be able to compute diffusion statistics (Fig. 2a). As can be seen in Fig. 2b, this deployment strategy provided a good coverage of the NMA basin during the period considered. The only regions with limited drifter data are the Gulf of Trieste and the coastal areas in the vicinity of the Croatian islands.

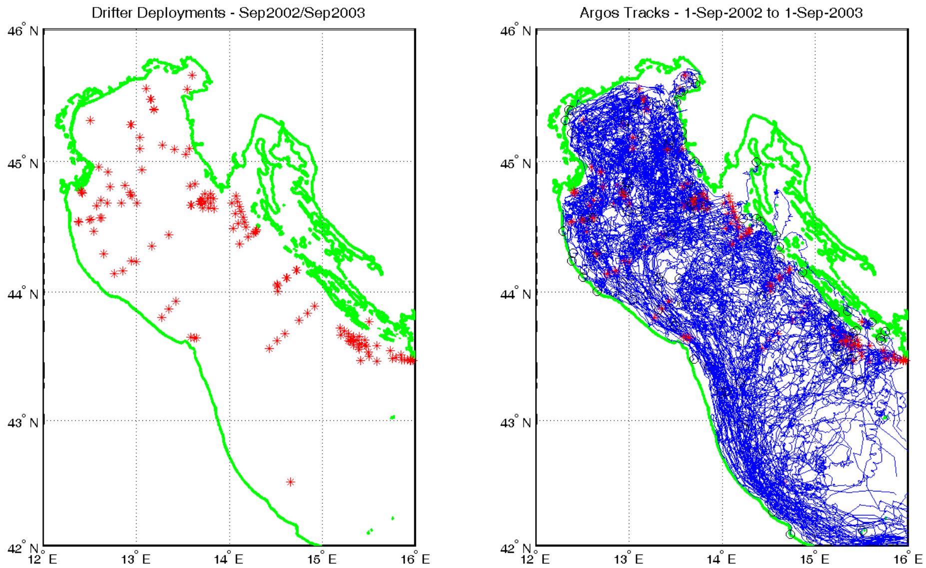

Fig. 2. Deployment locations (left) and edited Argos trajectories (right) in the NMA between 21 September 2002 and 31 August 2003. Start and end points of the trajectories are denoted by star and open circle circles, respectively.

3) Thermal and optical data: Drifters with thermistor chains and with optical instruments were operated during the R/V Knorr DV1 and DV2 cruises. An example of temperature data for the period 29 May and 4 June 2003 is shown as Fig. 3. The warming of the surface layer above 10 m depth is evident (about 3°C over 6 days). In contrast, the temperature at levels below 25 m depth appears to decrease slightly (by about 0.1°C/day).

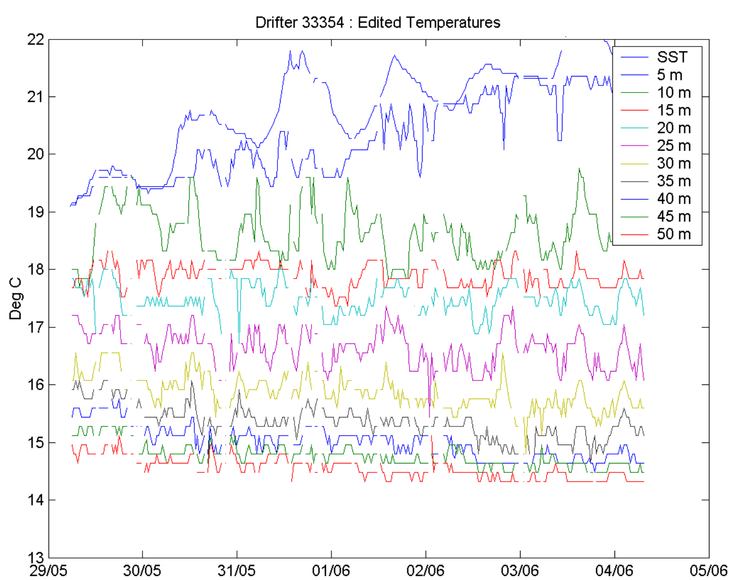

Fig. 3. Temperatures versus time for drifter 33354 between 29 May and 4 June 2003 spanning the top water column between the surface (SST) and 50 m depth.

The optical data measured by drifters in February 2003 are shown in Fig. 4. Spectra of the upwelling radiances are typical of oligotrophic waters near the Croatian coast (on 12-Feb-03) whereas in the Po plume (on 20-Feb-03) they delineate clearly the shift of color towards green. When scaled by the downwelling irradiance to compute the remote sensing reflectance, the spread of the lines due to the different hours of the day is much reduced as expected.

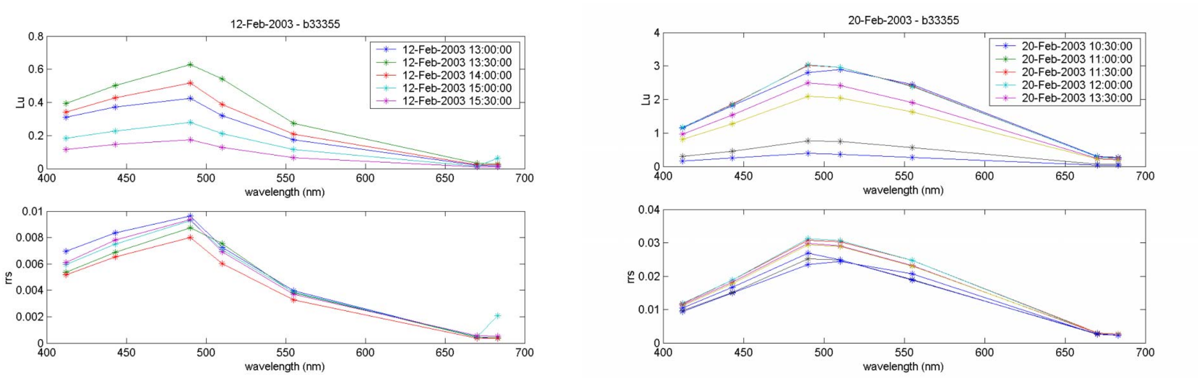

Fig. 4. Upwelling radiance (μW/cm^2 /nm/sr) data for drifter 33356 on 12 (top left) and 20 (top right) February 2003 for 7 channels in the visible band. The corresponding spectra of remote sensing reflectance are shown in the bottom panels.

IMPACT/APPLICATION

The scientific impact of this project will be to increase our understanding of the Adriatic dynamics and of the major forcing mechanisms. Future application could be the assimilation of the drifter data into numerical models in the framework of operational oceanography projects, such as the Adriatic Sea Integrated Coastal Areas and River Basin Management System (ADRICOSM) and the Mediterranean Forecasting System (MFSTEP) projects.

TRANSITIONS

This program will set up a new methodology using drifters, high-frequency coastal radars and remote sensing to study the mesoscale variability in any coastal environments and marginal seas. It is planned to assimilate the drifter and radar data into various numerical models of the Adriatic circulation to improve forecasting skills.

RELATED PROJECTS

1) This project is strongly related to, and fully integrated in, several other projects sponsored by ONR and other funding agencies. These programs include:

a. The ACE program (bottom-mounted ADCPs, surface salinity monitoring by airplane);

b. The ADRIA02 and ADRIA03 cruises onboard NRV Alliance of the NATO SACLANT Undersea Research Centre;

c. The EACE program focusing on the eastern Croatian coast (http://www.izor.hr/eace/);

d. A high-frequency coastal radar program on the western Italian coast (http://doga.ogs.trieste.it/doga/sire/dolcevita/radar.html; http://satftp.soest.hawaii.edu/hfradar/);

e. Two cruises onboard R/V Knorr (DV1 and DV2, towed vehicles, monitoring of optical properties) (http://www.apl.washington.edu/projects/adriatic_sea/summary.html; http://king.usc.edu/amex.htm)

f. A modeling program on the Adriatic mesoscale variability (http://thayer.dartmouth.edu/other/adriatic/).

2) The drifter data collected will be used by Drs. A. Griffa and T. Ozgokmen to validate their theoretical studies of particle dispersion (ONR supported project).

RELATED PROJECTS

Technical Reports:

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Poulain, P.M., L. Ursella, E. Mauri and D. Deponte (2003) DOLCEVITA-1 Cruise 31 January - 24 February 2003 Report of drifter-related activities, Rel. 08/2003/OGA/03, OGS, Trieste, Italy, 32 pp.

Poulain, P.M. and R. Barbanti (2003) DOLCEVITA-2 Cruise 26 May - 15 June 2003 Report of drifter-related activities, Rel. 29/2003/OGA/11, OGS, Trieste, Italy, 17 pp.

Papers:

Zatsepin, A. G., A. I. Ginzburg, A. G. Kostianoy, V. V. Kremenetskiy,V. G. Krivosheya, S. V. Stanichny and P.-M. Poulain (2003) Observations of Black Sea mesoscale eddies and associated horizontal mixing, Journal of Geophysical Research, Vol. 108, C8, 3246, doi:10.1029/2002JC001390.

Maurizi, A., A. Griffa, P.-M. Poulain and F. Tampieri (2003) Lagrangian turbulence in the Adriatic Sea as computed from drifter data: Effects of inhomogeneity and nonstationarity, Journal of Geophysical Research, submitted.